

GAS BEARINGS AND MAGNETIC BEARINGS FOR OIL-FREE ROTATING MACHINERY

Luis San Andrés

Mast-Childs Tribology Professor
Turbomachinery Laboratory
Texas A&M University
Lsanandres@tamu.edu

Daniel Lubell

Manager,
Rotating Machinery,
CALNETIX Technologies.
drlubell@yahoo.com

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Luis San Andrés, Texas A&M University
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11. IMPLEMENTATION OF FOIL GAS BEARINGS IN A MICRO GAS TURBINE SYSTEM.
A Gen. III foil bearing for a mass production micro turbine. A perspective from a successful commercial application of oil-free technology in microturbines from 30 kW up to 200 kW as well as development testing with blowers, compressors, air cycle machines, and more. Experience-based lessons on what-to-do and what-not-to-do related to implementation at the design level, including recommended operating spaces for the least risk. Expectations for bearing performance and assembly at the mass production level. Discussion of common failure modes.
12. INTRODUCTION TO MAGNETIC BEARINGS FOR SMALL AND MEDIUM SIZE TURBOMACHINERY SYSTEMS
A review of the components and operating principles of Active Magnetic Bearings (AMBs) as applied to the same size machinery as foil bearings. Additional discussion of expected performance through the review of a commercial system and associated challenges with integrating AMBs into next-generation turbomachinery.

Gas bearings (GBs) are an efficient alternative for load support of high speed microturbomachinery (< 400 kW, $+1000^{\circ}\text{F}$, $+3\text{M}$ DN). These bearings are compliant surface hydrodynamic bearings using ambient air as the working fluid media. Oil-free systems have lesser part count, footprint and weight and are environmentally friendly and (nearly) maintenance free, thus saving costs and resources. Current commercial applications include air cycle machines, cryogenic turbo expanders and micro gas turbines. Other upcoming applications include auxiliary power units, automotive turbochargers and aircraft gas turbine engines for regional jets.

The short course provides practicing engineers with a comprehensive review of existing gas bearing technologies including their principle of operation, analysis and experimental verification, comparison amongst other gas bearing types, as well as the integration of gas bearings, foil bearings in particular, into actual rotor-bearing systems (hot and cold). The course also includes an introduction to magnetic bearings and their applications in oil-free microturbomachinery.

THE AUTHORS



Luis San Andrés Mast-Childs Tribology Professor, Turbomachinery Laboratory, Mechanical Engineering Department, Texas A&M University

Lsanandres@tamu.edu

Luis San Andrés is a renowned analyst and experimentalist in the fields of fluid film lubrication and rotordynamics. Since 2000, Dr. San Andrés has performed research on the analysis and experimental verification of gas foil bearing performance for high temperature oil free turbomachinery and squeeze film dampers for aircraft jet engines. His computational codes, benchmarked against test data, are standards in the rotating machinery industry. Dr. San Andrés and his students have published over 150 papers and participate actively in international conferences and journal editorial boards. Learn more about his

work at <http://rotorlab.tamu.edu>.

Prof. San Andrés is an ASME Fellow and STLE Fellow and a member of the Advisory Committee for the Houston-Turbomachinery Symposium and Middle Eastern-Turbomachinery Symposium. He presently coordinates the organization of the 2016 Asia Turbomachinery Symposium in Singapore.

Daniel Lubell, Manager of Rotating Machinery, Calnetix Technologies

DLubell@calnetix.com and DRLubell@yahoo.com



Daniel Lubell has over 15 years of oil-free turbomachinery experience. Most recently, Daniel joined Calnetix in 2012 as part of the turbomachinery team. This role includes managing a small group of turbomachinery and electronics engineers and specialists in the development and commercial support of advanced oil-free turbomachinery with magnetic bearings and oil lubricated turbomachinery. Previously, Daniel was with Capstone Turbine in the oil-free foil bearing group. His roles included Manager of Turbomachinery Rotating Systems and Principal Engineer of Oil-Free Bearing Technology as part of a company focus on advancing foil bearing technology. His responsibilities included bearing and rotordynamic design integration and testing for all Capstone products as well technical and commercial lead for all outside foil bearing programs. Prior small turbomachinery

experience includes APU's and small thrust jets with Hamilton Sundstrand (now part of Pratt and Whitney).

Daniel has a Master of Science degree in Mechanical Engineering which he earned at the Texas A&M University Turbo Lab in College Station, Texas. Prior to that, he earned a Bachelor in Engineering Science degree from Trinity University in San Antonio, Texas. Daniel is an ASME member and active participant in conferences and journals and has published papers on squeeze film dampers and foil bearing developments for micro gas turbines.